Mechanisms of allergic diseases
(Supported by an educational grant from Merck & Co., Inc.)

Series editors: Joshua A. Boyce, MD, Fred Finkelman, MD, William T. Shearer, MD, PhD, and Donata Vercelli, MD

Addressing asthma health disparities: A multilevel challenge

Glorisa Canino, PhD,[a] Elizabeth L. McQuaid, PhD,[b] and Cynthia S. Rand, PhD[c] *San Juan, Puerto Rico, Providence, RI, and Baltimore, Md*

INFORMATION FOR CATEGORY 1 CME CREDIT

Credit can now be obtained, free for a limited time, by reading the review articles in this issue. Please note the following instructions.

Method of Physician Participation in Learning Process: The core material for these activities can be read in this issue of the Journal or online at the JACI Web site: www.jacionline.org. The accompanying tests may only be submitted online at www.jacionline.org. Fax or other copies will not be accepted.

Date of Original Release: June 2009. Credit may be obtained for these courses until May 31, 2011.

Overall Purpose/Goal: To provide excellent reviews on key aspects of allergic disease to those who research, treat, or manage allergic disease.

Target Audience: Physicians and researchers within the field of allergic disease.

Accreditation/Provider Statements and Credit Designation: The American Academy of Allergy, Asthma & Immunology (AAAAI) is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide continuing medical education for physicians. The AAAAI designates these educational activities for a maximum of 1 *AMA PRA Category 1 Credit*™. Physicians should only claim credit commensurate with the extent of their participation in the activity.

List of Design Committee Members: *Authors:* Glorisa Canino, PhD, Elizabeth L. McQuaid, PhD, and Cynthia S. Rand, PhD

Activity Objectives

1. To identify minority populations at highest risk for asthma prevalence, severity, and morbidity.
2. To learn that asthma disparities have multiple, complex, and interrelated sources.
3. To understand how the health care system, social/environmental factors, provider and individual attitudes, and behaviors play a role in asthma disparity.
4. To learn strategies that could be applied in the clinical setting to reduce asthma disparity.

Recognition of Commercial Support: This CME activity is supported by an educational grant from Merck & Co., Inc.

Disclosure of Significant Relationships with Relevant Commercial Companies/Organizations: E. L. McQuaid has received research support from the National Institute of Nursing Research and the National Heart, Lung, and Blood Institute. C. S. Rand has served as a scientific advisor for the Merck Foundation and the Schering-Plough Leadership Council. G. Canino has declared that she has no conflict of interest.

Substantial research has documented pervasive disparities in the prevalence, severity, and morbidity of asthma among minority populations compared with non-Latino white subjects. The underlying causes of these disparities are not well understood, and as a result, the leverage points to address them remain unclear. A multilevel framework for integrating research in asthma health disparities is proposed to advance both future research and clinical practice. The components of the proposed model include health care policies and regulations, operation of the health care system, provider/clinician-level factors, social/environmental factors, and individual/family attitudes and behaviors. The body of research suggests that asthma disparities have multiple, complex, and interrelated sources. Disparities occur when individual, environmental, health system, and provider factors interact with one another over time. Given that the causes of asthma disparities are complex and multilevel, clinical strategies to address these disparities must therefore be comparably multilevel and target many aspects of asthma care. Several strategies that could be applied in clinical settings to reduce asthma disparities are described, including the need for routine assessment of the patient's beliefs, financial barriers to disease management, and health literacy and the provision of cultural competence training and communication skills to health care provider groups. (J Allergy Clin Immunol 2009;123:1209-17.)

Key words: *Asthma disparities, multi-level model of asthma disparities, clinical recommendations*

Substantial evidence across multiple avenues of research has documented pervasive asthma disparities between minorities and non-Latino whites (NLWs). Higher rates of asthma ***prevalence*** are consistently found among certain ***minority*** racial/ethnic groups, particularly African American, American Indian, and Puerto Rican populations.[1-3] There is also substantial evidence of

From [a]the Behavioral Sciences Research Institute and the Department of Pediatrics, University of Puerto Rico; [b]the Bradley/Hasbro Research Center, Brown Medical School, Providence; and [c]the Johns Hopkins School of Medicine, Baltimore.

Supported by National Institutes of Health grant no. 5P60 MD002261-02 funded by the National Center for Minority Health and Health Disparities and 5 U01 HL 072519-05 Canino (PI) and U01 HL 072438 Fritz (PI) from the National Heart, Lung, and Blood Institute.

Received for publication January 16, 2009; revised February 5, 2009; accepted for publication February 6, 2009.

Available online May 18, 2009.

Reprint requests: Glorisa Canino, PhD, Behavioral Sciences Research Institute, Medical Sciences Campus, PO Box 365067, San Juan, Puerto Rico 00936-5067. E-mail: Glorisa.canino@upr.edu.

0091-6749/$36.00

doi:10.1016/j.jaci.2009.02.043

Terms in boldface and italics are defined in the glossary on page 1210.

Abbreviations used
ED: Emergency department
ICS: Inhaled corticosteroid
NLW: Non-Latino white
SES: Socioeconomic status

worse asthma control among minority populations compared with that seen among NLWs, including significantly higher rates of asthma exacerbations and missed days from school or work,[4-6] greater rates of emergency department (ED) use,[7-9] higher hospitalization rates,[9-12] and greater asthma mortality risk.[13,14]

Although the literature on asthma disparities is evolving rapidly, considerably more research has been conducted with certain minority groups, such as African Americans and Latinos, compared with others, such as Native Americans. Additionally, the manifestation of disparities across different racial/ethnic groups can differ substantially. For example, Latinos of Mexican origin present with lower asthma prevalence and morbidity compared with whites,[1,2] and children of African American and Puerto Rican origin appear to have the highest prevalence compared with NLWs,[3] with Puerto Ricans exhibiting the highest prevalence of any other ethnic/racial group.[1] On the other hand, African Americans demonstrate higher rates of hospitalization[9,10,12,15] and higher rates of asthma mortality[13,14] compared with NLW and Latino populations. These findings suggest that what constitutes "disparity" might differ by racial/ethnic group.

Although ethnic/racial disparities in asthma have been well established, the underlying causes of these disparities are poorly understood, and as a result, the leverage points to address them remain unclear. In the present article we present a brief review of current findings that have emerged in key areas of research on health care disparities in asthma and propose a multilevel framework for integrating this substantial literature. Our model is derived from the Institute of Medicine's 2002 landmark report on unequal care, which focused on health care policies and regulations, operation of the health care system, and provider/clinician-level factors. In addition to these health care system factors, we also consider broader social/environmental factors and individual/family attitudes and behaviors that might have a role in asthma disparities. Below we present empiric support for the processes included in the main domains of our proposed model and suggest how this model can be helpful in advancing both future research and clinical practice.

HEALTH CARE POLICY FACTORS

There is evidence that certain health care policies might contribute to disparities in asthma outcomes and that cost-control

GLOSSARY

ASTHMA ACTION PLAN: A written asthma plan, including peak flows, symptoms, and medications, can change asthma exacerbations and urgent care visits, especially if used in conjunction with a more intensive asthma education program.

CULTURAL COMPETENCE TRAINING: An increased emphasis on understanding cultural barriers to health care has led to the development of specific programs, especially at the medical school level, to teach the health care effect of cultural differences. There are standardized assessment tools to gauge cultural training and online courses to meet cultural competency requirements. Although studies have shown that cultural competence training can improve cultural understanding among medical providers, the effect of such training on health outcomes for patients continues to be assessed.

DISPARITIES MODELS: Disparities models are theoretic models used to explain health disparities among patient populations. Examples include the racial-genetic model, the health behavior model, the SES model, and the psychosocial stress model. These models can then be compared with one another by using multivariate analysis to assess which differences most accurately account for health disparities between racial and ethnic groups.

GENETIC RISK FACTORS: Studies on the genetics of asthma include the discovery of genes that predispose to asthma, genes that interact with the environment to predispose to asthma, and pharmacogenomics (ie, the likelihood of therapeutic response based on genetics). Gene-environment examples include the relationship between environmental tobacco smoke exposure and genes involved in oxidative stress (*GSTM1* and *GSTM2*) and immunity genes (*CD14* and *IL13*). A recent large population study shows early-onset asthma susceptibility, especially with concurrent exposure to tobacco smoke, associated with genes on chromosome 17q21.1.

HOME REMEDIES: Cultural beliefs change a patient's view about asthma causes, and these beliefs might lead to the institution of home remedies before or instead of seeking traditional medical care. For example, Latino patients can believe that asthma is caused by strong emotions and an imbalance of hot and cold and might treat asthma with behavior changes, physical remedies (eg, rubbing the back), and herbal teas or syrups. In time, some culture-specific remedies have proved to have significant medical utility, such as Chinese herbal therapy for the treatment of food allergy and asthma.

MEDICAID: Created in 1965 as part of the Social Security Act, Medicaid is a program to provide health care to low-income families. States can have various names for Medicaid, including MassHealth (Massachusetts) and Medi-Cal (California). Other government-run health care systems include Military Health Systems, CHIP (see below), TRICARE, and the Department of Veterans Affairs.

MINORITY: The Office of Minority Health and Health Disparities of the Centers for Disease Control and Prevention defines racial and ethnic minorities as American Indian and Alaska Native populations, Asian American populations (Far East, Southeast Asia, and Indian subcontinent), black or African American populations, Hispanic or Latino populations (Cuban, Mexican, Puerto Rican, and South/Central American), Native Hawaiian, and other Pacific Islander.

PREVALENCE: Prevalence is defined epidemiologically as the number of persons in the population with a disease at a given time divided by the number of persons in the population at risk for the disease plus the number of persons with the disease. Unlike incidence, prevalence reflects cumulative cases rather than the new cases of a disease in a given population over a period of time.

SECOND HAND SMOKE: Environmental tobacco smoke exposure is associated with increased asthma symptoms, increased medical visits, and decreased lung function in asthmatic subjects. Animal models demonstrate that exposure to passive cigarette smoke (or smoke extract) increases allergic sensitization to ovalbumin.

SOCIOECONOMIC STATUS: A combination of factors determines a person's SES, including occupation (unemployment), income (poverty line and median household income), education level, wealth (property values), and housing (crowded). The current poverty guideline for the 48 contiguous states for a family of 4 is $22,050.

S-CHIP: The State Children's Health Insurance Program (now known as CHIP) was created in 1997 to provide health insurance to children who were ineligible for Medicaid but who could not afford private health insurance. In February 2009, the Children's Health Insurance Program Reauthorization Act (CHIPRA) was signed into law to extend and expand CHIP.

The Editors wish to acknowledge Seema Aceves, MD, PhD, for preparing this glossary.

strategies implemented by public health plans might differentially affect minority populations. Minorities are overrepresented in government-sponsored health plans, such as Medicare, which are federally and state regulated for cost control. As a result, minority populations might receive restricted access to specialists and preventive care, thus resulting in lower quality of health care.[16,17]

Access to care

Factors common to publicly insured plans, such as decreased use of preventive care and limited referrals to asthma specialists, have been associated with higher rates of hospitalization and ED use and increased risk of mortality.[18,19] Restricted access to specialists might contribute to disparities in asthma morbidity, given that there is evidence that specialists are more likely to prescribe controller medications than primary care providers independent of the patient's minority status.[19,20]

Eligibility and copayment

In an effort to control costs, many states have enacted policies to reduce ***Medicaid*** eligibility and manage prescription drug benefits, either by decreasing the payments to pharmacies or by introducing copayments.[16] There is preliminary evidence that the introduction of these restrictions might negatively affect asthma outcomes among minorities and the poor,[16] hence increasing existing disparities. In support of this notion, one study demonstrated that doubling existing copayments resulted in a 21% reduction in the number of prescriptions filled for asthma.[21] Rand et al[22] found that among African American families covered by Medicaid, out-of-pocket payments for health care were an important predictor of ED use for an asthma exacerbation. These findings suggest that increasing out-of-pocket costs to disadvantaged groups might diminish access to medication and to appropriate strategies for preventive management of exacerbations.

OPERATION OF THE HEALTH CARE SYSTEM

Adherence with guidelines

National guidelines[23] continue to stress that families and health care providers should collaborate actively to manage asthma, with an emphasis on preventive management. Preventive management includes strategies to avert asthma episodes through control of relevant environmental triggers, regular use of controller medications for patients with persistent symptoms, use of an ***asthma action plan***, and referrals to specialists when indicated. In addition, assessment of asthma severity at initial presentation should guide treatment initiation, with repeated assessments of asthma control to determine whether relevant treatment adjustments need to be made. Research demonstrates that many health care providers have difficulty adhering to these established guidelines,[24-26] particularly providers who treat minorities.[27]

There is evidence that providers often fail to provide a prescription for controller medications, even when children present with symptoms of persistent asthma,[28] and that this underprescription of controller medication is even more pronounced for minority children compared with NLWs.[29,30] In a recent study of prescription practices of pediatricians treating children with mild persistent asthma, pediatricians in practices with more than 25% African American children in their practice reported prescribing daily use of controller medications less frequently (31%) than pediatricians in all practices (51%).[31] Other research has shown that African American and Latino children are less likely to have inhaled corticosteroids (ICSs) prescribed during an ED visit and less likely to have an ICS prescription filled before the ED visit compared with NLWs.[8,9,32]

Practice policies

Practice policies within the managed care Medicaid setting might also have an effect on asthma outcomes. For example, Lieu et al[33] found that settings in which the organization provided reports about asthma screening to physicians, promoted access and continuity of care, and implemented ***cultural competence training*** for staff had better asthma outcomes and higher patient-rated quality of care after adjusting for patient demographics and baseline asthma status. In practice settings that promoted these policies, patients were less likely to underuse controller medications and demonstrated better indicators of physical status at follow-up.

HEALTH PROVIDER/CLINICIAN FACTORS

Although less commonly studied, it should be acknowledged that individual provider characteristics and beliefs have the potential to contribute to disparities in asthma outcomes. The Institute of Medicine report[17] proposes that although most providers intend to provide equitable care, subtle forms of discrimination might contribute to disparities in health care. The report proposes 3 mechanisms that might produce discriminatory provider practices: unintentional bias against minorities in interpreting the patient's symptoms and in decision making, greater clinical uncertainty when interacting with minority patients, and beliefs or stereotypes held by the provider. Unintentional bias results from the marked differences that often exist between physicians and patients belonging to other socioeconomic classes or racial/ethnic groups. Physicians are likely to share the same beliefs or stereotypes of minorities shared by the culture in which they live, and these in turn might affect the care they give. These 3 sources of practice bias are more likely to occur when physicians have poor understanding of the patient's ethnic and cultural disease models and limited knowledge of patient preferences regarding disease management approaches.[34] In what follows we provide some evidence that minorities with asthma might receive poorer treatment within the clinical encounter compared with NLWs with asthma.

Bias/stereotyping

Asthma is a disease for which assessment of the current level of asthma severity is crucial for appropriate treatment. Provider assessment and interpretation of patient-reported symptoms are crucial in determining the asthma severity level. Thus ineffective provider communication often results in misclassification of asthma symptom severity among minority patients. One study of patients enrolled in 15 managed care organizations showed that underclassification of asthma severity by physicians was significantly more common among African Americans than among NLWs and that this underestimation was associated with lower patient use of ICSs.[35]

Providers might unconsciously behave in ways that confirm their stereotypes, even though consciously they intend to provide equal treatment.[36] For example, some physicians believe that African Americans are less adherent with treatment,[37] a notion that

could lead to lower prescription rates of controller medications and less emphasis on preventive education. Although this belief is supported by research showing that African Americans and other minorities are less likely to adhere to medication,[38,39] these findings do not reflect the behavior of all members of a group and should not be used to predict individual patient's behaviors. Furthermore, nonadherence might result from remediable but often hidden barriers, such as inadequate patient education, health beliefs, or poor health literacy. Physicians who communicate effectively and get to know their patients as unique individuals will therefore be best able to identify and address patient barriers to adherence.

Cultural competence

Providers' greater misclassification of severity for minority groups might be due to cultural differences. Asthma treatment relies on the accuracy of the patient's symptom reporting and provider comprehension and interpretation of those reports for appropriate diagnosis and treatment. When the family and provider come from different cultural backgrounds, speak different languages, or both, difficulties in the cross-cultural communication might compromise the acquisition of the necessary information to make an accurate diagnosis or assess severity, develop a trusting relationship, and treat adequately.[40-42] Research in this area is limited, and although investigations of the contribution of limited cultural competence and provider bias to asthma disparities might be challenging to implement, such research could provide greater insight into the mechanisms underlying disparities in disease management behavior and outcomes for patients with asthma.

INDIVIDUAL/FAMILY FACTORS

Emerging research has examined the role that biologic and ***genetic risk factors*** might play in asthma disparities.[43,44] Although these inherent risk factors likely contribute to susceptibility, severity, or both, it is also clear that substantial variation in asthma outcomes might be mediated through the influence of individual behavioral and psychosocial differences on self-management. We describe below these potentially modifiable individual/family factors that might contribute to asthma disparities.

Health beliefs

Given that one of the most central recommendations for management of persistent asthma symptoms is the use of daily controller medications and that the use of quick-relief medications is recommended for all patients with asthma,[45] attitudes toward medication use are an important factor to consider in understanding disparities in disease management and course.

Attitudes toward medication affect the use of both physician-recommended and alternative medications and, ultimately, health outcomes. For example, use of ***home remedies*** to manage asthma has been reported frequently among Latinos[46,47] and African Americans.[48,49] The use of home remedies as an initial response to symptoms might delay timely treatment, causing symptoms to progress and become more severe. There is evidence that many patients never tell their physicians about the use of home remedies[50] and that greater discussion of how to integrate home remedies with conventional asthma treatment would be well received by patients with asthma.[48]

In addition to use of alternative medications, there is some evidence that general beliefs about medication efficacy and concerns about medication use vary widely by ethnicity. One qualitative study with African American parents documented numerous concerns and barriers to medication use.[49] Parents noted many concerns about medication and side effects, such as the belief that children would become addicted to asthma medicines. A recent survey study[51] indicated that relative to nonminority parents of children with asthma, minority parents' concerns about medication more frequently outweighed belief in the need for medication. Other research has indicated that Latino and NLW parents hold different beliefs in medication necessity relative to concern, with Latino parents acknowledging higher levels of concern about medication use and addiction in relation to medication necessity.[52]

Adherence with therapy

Even if families receive and fill a prescription for controller medication, adherence is generally poor[53] and most compromised among minority patients.[38,39] In one early study Apter et al[38] found adherence to ICSs among adults with moderate-to-severe asthma to be approximately 63% of the prescribed doses. Racial/ethnic minority status, Spanish as the primary language, and poor patient-clinician communication were all associated with poor adherence.[38] In another more recent study, African American adults were found to have low ICS adherence relative to NLWs (40% vs 58%).[54] Studies with pediatric groups demonstrate a similar pattern. A recent investigation found that minority children (predominately African American) took significantly fewer doses of inhaled steroids relative to nonminority children (35% vs 62% of prescribed doses, respectively).[55] Another study found a similar difference in medication adherence rates between minority and nonminority children with asthma (37% vs 53% of prescribed doses, respectively), and that these differences remained when controlling for ***socioeconomic status*** (SES).[56]

There is some evidence that the concerns about medications more frequently held by minorities might be a factor in low medication adherence; however, study findings have been mixed. In one study negative beliefs were associated with poor self-reported adherence among parents of children with asthma, although actual medication use was not measured.[51] Among adults with asthma, there is some indication that medication beliefs might mediate the association between minority status and low adherence to ICSs and that "readiness to take an ICS" might predict adherence for African Americans with asthma.[57] In other words, culturally different medication beliefs might be a factor in explaining the observed association between minority status and low adherence to ICSs. Another study, however, found that although attitude toward ICS use was predictive of adherence, it did not mediate the association between race-ethnicity and adherence.[58] Negative beliefs about controller medications and associated underuse might be an important factor in the observed ethnic disparities in asthma morbidity; however, the mechanisms through which these factors interface with other sources of disparity, such as health care access and financial resources, merit further investigation.

Health literacy

Health literacy might also be a barrier to patient understanding of physician-provided educational information. In one study of

elderly patients insured by a large private health care plan, 33.9% of English-speaking and 53.9% of Spanish-speaking respondents were found to have inadequate or marginal health literacy.[59] Poor health literacy is also more common among low-income and minority patients.[60] Substantial research has confirmed that low health literacy is associated with overall poorer health outcomes for several conditions, including asthma.[60,61] There is some evidence that providing tailored asthma self-management education can be a useful strategy among low-literacy adults with asthma,[62] suggesting that how providers identify and communicate with patients with low health literacy might have an effect on disease management outcomes.

SOCIAL/ENVIRONMENTAL FACTORS

Americans with low SES, whether measured based on income or occupation, have higher levels of illness than higher-income populations.[63] Persons with low incomes in general have poorer health and shorter life expectancy.[64] For certain racial groups, such as African Americans, mortality rates in almost every illness, including asthma, are higher than those seen in whites independent of income level.[63] Furthermore, minorities and individuals with low SES are more likely to engage in high-risk behaviors associated with asthma exacerbations, such as smoking, and are also less likely to quit smoking than high-income populations.[65,66]

It is well known that the vast majority of minorities live in neighborhoods where most families are below the federal poverty level and in segregated neighborhoods where the majority of families belong to the same minority group.[67,68] Although poverty has been associated with poor health in general, in the case of asthma, the evidence has been equivocal, with 3 studies finding an association between neighborhood poverty and increased asthma prevalence independent of individual risk factors,[64,68] and 2 other studies finding no association, particularly for Hispanic adults.[67,69]

It is well demonstrated, however, that individuals of low SES often live in urban neighborhoods characterized by greater exposure to environmental toxins and violence and higher levels of stress.[70] A growing number of studies have shown that these multiple social and economic stressors characteristic of poor urban neighborhoods affect health independent of individual vulnerabilities.[71,72]

Environmental factors

Housing in impoverished areas is more likely to have above average exposure to indoor allergens, such as dust mite, rodent allergens, cockroach allergens, mold, and mildew.[64,73] Low-income communities have higher concentrations of buildings that emit environmental pollutants into the ambient air.[74] Although it is not clear whether air pollutants cause asthma, the level of air pollution is correlated with morbidity of respiratory illnesses.[75] Minority children are also significantly more likely to be exposed to ***second hand smoke***, which is a known contributor to asthma prevalence and morbidity.[76,77]

Stress/violence

Residents of poor neighborhoods might experience stress related to lack of neighborhood safety, violence, and discrimination.[78] There is increasing evidence that stress might influence the onset and course of asthma, particularly for those in urban environments. In addition, levels of maternal stress[79] and distress[80] have been associated with increased risk for asthma onset. Stress related to exposure to violence in high-risk neighborhoods has been associated with asthma exacerbations.[81] Several other studies have found an association between stress, asthma, and atopy.[82-84] In one novel study chronic stress was associated with immunologic profiles in a sample of children with asthma.[85] Specifically, the pathway between SES and immune function (higher production of IL-5 and increased eosinophil counts) was explained by differences in chronic stress and threat perception.

Depression

Poverty is linked with a markedly higher risk of depression.[86] An emerging literature links depression in low-income individuals with less confidence in asthma treatment effectiveness; less self-efficacy to cope with asthma episodes; poor adherence to therapy; higher use of emergency, hospitalization, and outpatient services; higher functional impairment; higher number of asthma episodes; and decreased use of preventive services.[87-89]

Stress and socioeconomic disadvantage clearly increase the risk for asthma and place additional burdens on asthma management. One recent study of urban children with asthma found that although poverty was independently associated with increased risk for asthma morbidity, a cumulative risk index consisting of multiple risks associated with urban neighborhoods (eg, neighborhood unsafety), urban living (eg, exposure to environmental tobacco smoke), and cultural experiences (eg, acculturative stress) accounted for additional variance in morbidity indexes than poverty alone.[47] These findings suggest that models that attempt to depict social and economic influences on asthma outcomes among minority groups will need to capture multiple levels of risk.

MULTILEVEL CONCEPTUAL MODEL FOR EXPLAINING AND ADDRESSING ASTHMA DISPARITIES

The body of research in this area suggests that no single risk factor has emerged as the primary cause of disparities. Instead, asthma disparities have multiple, complex, and interrelated sources. Therefore to move forward in our understanding of asthma disparities and development of effective interventions, it will be necessary to frame our future research within a conceptual model that incorporates a range of risk factors at multiple levels of influence.

We propose a multilevel, multifaceted conceptual model to explain the mechanisms involved in the observed disparities in asthma treatment (Fig 1). The model is based on an expanded definition of the Institute of Medicine model that depicts disparities as racial and ethnic differences in access, health care quality, or health care outcomes not due to differences in appropriateness of care, health status, or patient preferences.[17,90] This definition considers racial/ethnic disparities as requiring remediation even if they arise through differences in income, insurance, and other mechanisms outside the clinical condition.[91] Given that the effect of social class in explaining disparities is likely to be as potent as that of race/ethnicity and that there are likely to be interactions between class and ethnicity,[92] we include income and access factors as important contributors to asthma disparities.

The key domains relating to the health care system are depicted on the left side of Fig 1. As in our previous model[4] and because of the increasing evidence of genetic and biologic differences related

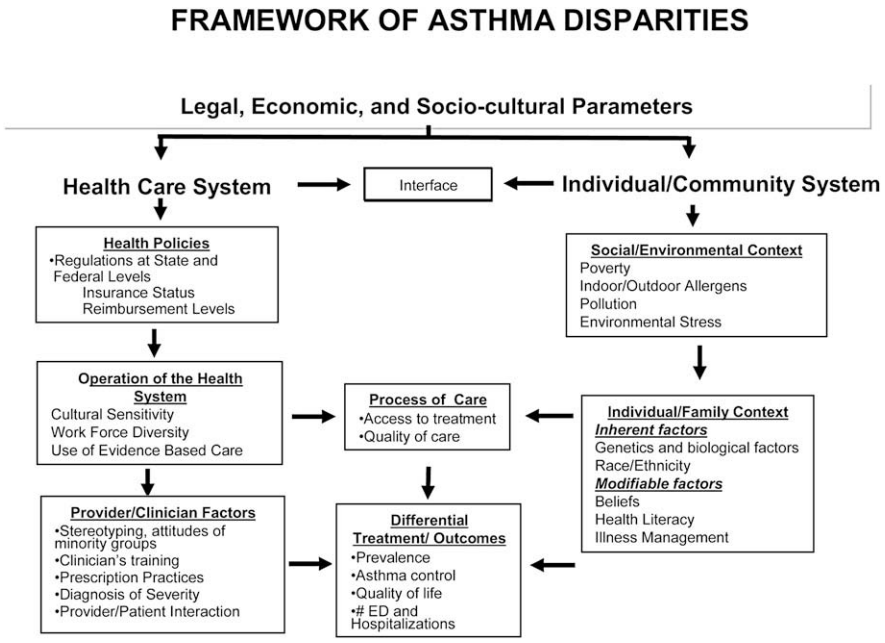

FIG 1. Multilevel asthma disparities model.

to the risk for asthma and its course, we add emphasis on individual-level variables, as well as individual-based processes that are modifiable but might contribute to disparities (eg, medication beliefs and illness management behaviors). Additionally, we include a fourth domain of external environmental factors (eg, indoor/outdoor allergens, pollution, and neighborhood stresses), which might be particularly critical for the onset and progression of asthma (Fig 1, right). The components within and across the domains are assumed to interact with each other to affect the process of care that, in turn, influences disparity outcomes.

PRACTICAL IMPLICATIONS OF APPLYING A MULTILEVEL ASTHMA *DISPARITIES MODEL* FOR RESEARCH AND CLINICAL PRACTICE

It is apparent from this review that understanding ethnic disparities, cultural disparities, or both in asthma morbidity and prevalence is a complicated process. Although multiple risk factors have been identified, no single variable directly accounts for large differences in outcomes. If we are to reduce asthma disparities, there is a need to obtain a better understanding of the complex ways in which multiple variables interact and the relative weight that each one contributes to inequalities in asthma morbidity and prevalence. Research that examines the complex relationships among factors at the socioeconomic, health system, and individual level that increase the risk for poor asthma outcomes among the poor and racial/ethnic minorities is needed.

For example, it is possible that genetic variations in medication response found among some African Americans and some subgroups of Latinos with asthma[44,45] might relate to individual beliefs about the efficacy of medication. The process of care in which these beliefs are discussed and addressed is shaped by the health care literacy of the patient, the health care system, and elements of the patient-provider interaction (eg, provider biases about patient receptivity to medication use). Health care policies then influence the accessibility of medication to patients. Asthma management occurs through multiple channels, and to truly understand the mechanisms underlying health care disparities, we need to use a broad lens to consider the wide range of influence on health care behavior. For this reason, the next generation of research will require a more sophisticated analytic tool box that incorporates such strategies as multilevel modeling.[93]

It is important to note that some domains within the model might be more important or modifiable than other domains. For example, although genetic factors clearly influence the onset and expression of asthma,[2,43] other factors, such as those within the health care system, the patient-provider relationship, and the individual/family domain, are more amenable to intervention. Research regarding the efficacy and cost-effectiveness of treatment approaches that affect changes in these various levels of influence is needed to inform treatment course.

Culturally sensitive clinicians who are well trained facilitate effective communication with the family and provide the appropriate prevention education, intervention, and evidence-based treatment can offset many of the disparities related to asthma morbidity. Providers can make special efforts with minority children to monitor changes in clinical status and to modify therapy more frequently when needed. Clinicians might need to spend more time with minority patients so that they are able to better understand the patient's context, medication, and health beliefs that might be interfering with treatment adherence and to more effectively meet the needs of patients with low health literacy. We acknowledge, however, that this recommendation might be difficult to implement given the managed care health care policies in many states that require high productivity of providers to remain financially solvent.

Finally, asthma cannot be controlled effectively unless patients have affordable access to a full range of services and quality of care. Health policies can make insurance plans more accessible, expanding Medicaid and ***S-CHIP*** coverage and reimbursement to physicians, as well as reimbursing for prevention interventions that are culturally sensitive. Quality management strategies, such as "pay for performance," as well as electronic health

TABLE I. Clinical practice strategies to address asthma disparities

Disparity observed	Clinical practice strategies
Increased likelihood that health care providers will undertreat asthma	Incorporate routine clinic screening for asthma control Audit asthma treatment plans for appropriateness
Increased risk of patient nonadherence	Assess patients' treatment expectation and beliefs and concerns about asthma and asthma therapy Inquire about use of complementary medications or complementary therapies Routinely assess financial barriers to adherence Reduce or eliminate copays
Increased risk of patient-provider communication/ language barriers	Implement cultural competence and communication skills training for staff and physicians Increase availability of translators Increase work force diversity
Increased exposure to high-risk environments	Offer counseling and referral for smoking cessation/passive smoke avoidance assistance (eg, 1-800-QUITNOW) Public health departments might also offer free or low-cost programs Offer education on allergens and triggers
Increased risk of low health literacy	Avoid complicated medical terms Use "tell me back" strategy to confirm understanding Use low-literacy asthma educational materials
Increased risk of depression	Consider routine screening for depression with appropriate referral

records that facilitate monitoring, show promise to improve quality of care if implemented in Medicaid.[16]

CLINICAL IMPLICATIONS AND RECOMMENDATIONS

Our review of the literature and proposed model underscores that the causes of asthma disparities are complex and multilevel. Clinical strategies to address these disparities must therefore be comparably multilevel and targeted. We believe that disparities occur when individual, environmental, health system, and provider factors interact with each other in multiple ways and that these interactions can vary according to the person's particular needs that change with time. With this preamble in mind, we offer a number of suggestions that might begin to ameliorate the asthma disparities observed among ethnic/racial groups (Table I). The first step is for the clinician to acknowledge the complexity of the issues that might contribute to poor asthma outcomes among minorities.[94] Poor outcomes are often due to divergence between physician recommendations and the implementation of a treatment plan. Patients' lack of adherence to recommended treatment is likely related to a cascade of factors that include patient health literacy, medication beliefs, patient-provider communication, and health care access.

At the level of the provider group or clinic, clinical strategies that routinely assess asthma control and appropriateness of treatment, as well as interventions designed to improve provider-patient communication about patient preference, asthma beliefs, and barriers to care, are promising strategies for addressing the disparity observed in the quality of care received by minority populations.[33,95]

Population-based projections indicate that the proportion of the US population that is considered "minority" will continue to increase over the next several decades, ultimately surpassing the NLW majority by 2050.[96] In addition, increasing pressures on the economy might limit publicly available resources and initiate further restrictions on health care coverage, heightening the risk that existing disparities in asthma will not just continue but will increase. The most effective intervention for addressing asthma disparities would likely be the abolishment of poverty and racial bias. Until then, our asthma research and our clinical strategies will necessarily have to become increasingly integrated, multifaceted, and multilevel.

We thank Drs Greg Fritz and Barbara Jandasek from Brown University for their help.

REFERENCES

1. Lara M, Akinbami L, Flores G, Morgenstern H. Heterogeneity of childhood asthma among Hispanic children: Puerto Rican children bear a disproportionate burden. Pediatrics 2006;117:43-53.
2. Hunninghake GM, Weiss ST, Celedon JC. Asthma in Hispanics. Am J Respir Crit Care Med 2006;173:143-63.
3. Center for Disease Control and Prevention. The state of childhood asthma, United States: 1980-2005. Available at: www.cdc.gov/nchs. Accessed May 6, 2009.
4. Canino G, Koinis-Mitchell D, Ortega AN, McQuaid EL, Fritz GK, Alegria M. Asthma disparities in the prevalence, morbidity, and treatment of Latino children. Soc Sci Med 2006;63:2926-37.
5. Lieu TA, Lozano P, Finkelstein JA, Chi FW, Jensvold NG, Capra AM, et al. Racial/ethnic variation in asthma status and management practices among children in managed Medicaid. Pediatrics 2002;109:857-65.
6. Haselkorn T, Lee JH, Mink DR, Weiss ST. Racial disparities in asthma-related health outcomes in severe or difficult-to-treat asthma. Ann Allergy Asthma Immunol 2008;101:256-63.
7. Ginde AA, Espinola JA, Camargo CA Jr. Improved overall trends but persistent racial disparities in emergency department visits for acute asthma, 1993–2005. J Allergy Clin Immunol 2008;122:313-8.
8. Kruse LK, Deshpande S, Vezina M. Disparities in asthma hospitalizations among children seen in the emergency department. J Asthma 2007;44:833-7.
9. Shields AE, Comstock C, Weiss KB. Variations in asthma care by race/ethnicity among children enrolled in a state Medicaid program. Pediatrics 2004;113:496-504.
10. Akinbami L. The state of childhood asthma, United States, 1980–2005. Adv Data 2006;381:1-24.
11. Erickson SE, Iribarren C, Tolstykh IV, Blanc PD, Eisner MD. Effect of race on asthma management and outcomes in a large, integrated managed care organization. Arch Intern Med 2007;167:1846-52.
12. Gupta RS, Carrion-Carire V, Weiss KB. The widening black/white gap in asthma hospitalizations and mortality. J Allergy Clin Immunol 2006;117:351-8.
13. Akinbami LJ, Schoendorf KC. Trends in childhood asthma: prevalence, health care utilization, and mortality. Pediatrics 2002;110:315-22.
14. Homa DM, Mannino DM, Lara M. Asthma mortality in U.S. Hispanics of Mexican, Puerto Rican, and Cuban heritage, 1990–1995. Am J Respir Crit Care Med 2000;161:504-9.
15. Fisher-Owens SA, Turenne WM, Chavanu K, Slonim AD. Racial disparities in children hospitalized with asthma at Academic Childrens' Hospitals. Pediatr Asthma Allergy Immunol 2006;19:162-71.
16. Shields AE. Trends in private insurance, Medicaid/State Children's Health Insurance Program, and the health-care safety net: implications for asthma disparities. Chest 2007;132(suppl):818S-30S.
17. Smedley BD, Stith AY, Nelson AR. Unequal treatment confronting racial and ethnic disparities in health care. In: Committee on Understanding and Eliminating Racial and Ethnic Disparities in Health Care. Washington (DC): Board of Health Sciences Policy, Institute of Medicine; 2002.
18. Berman S, Armon C, Todd J. Impact of a decline in Colorado Medicaid managed care enrollment on access and quality of preventive primary care services. Pediatrics 2005;116:1474-9.
19. Joseph CL, Havstad SL, Ownby DR, Johnson CC, Tilley BC. Racial differences in emergency department use persist despite allergist visits and prescriptions filled for antiinflammatory medications. J Allergy Clin Immunol 1998;101:484-90.
20. Finkelstein JA, Lozano P, Farber HJ, Miroshnik I, Lieu TA. Underuse of controller medications among Medicaid-insured children with asthma. Arch Pediatr Adolesc Med 2002;156:562-7.

21. Goldman DP, Joyce GF, Escarce JJ, Pace JE, Solomon MD, Laouri M, et al. Pharmacy benefits and the use of drugs by the chronically ill. JAMA 2004;291: 2344-50.
22. Rand CS, Butz AM, Kolodner K, Huss K, Eggleston P, Malveaux F. Emergency department visits by urban African American children with asthma. J Allergy Clin Immunol 2000;105:83-90.
23. National Institutes of Health, National Heart, Lung, and Blood Institute. National Asthma Education and Prevention Program. Expert panel report 3: guidelines for the diagnosis and management of asthma. Washington (DC): National Institutes of Health; 2007. NIH publication no. 07-4051.
24. Cabana MD, Ebel BE, Cooper-Patrick L, Powe NR, Rubin HR, Rand CS. Barriers pediatricians face when using asthma practice guidelines. Arch Pediatr Adolesc Med 2000;154:685-93.
25. Diette GB, Skinner EA, Markson LE, Algatt-Bergstrom P, Nguyen TT, Clark RD, et al. Consistency of care with national guidelines for children with asthma in managed care. J Pediatr 2001;138:59-64.
26. Finkelstein JA, Lozano P, Shulruff R, Inui TS, Soumerai SB, Ng M, et al. Self-reported physician practices for children with asthma: are national guidelines followed? Pediatrics 2000;106:886-96.
27. Flores G, Lee M, Bauchner H, Kastner B. Pediatricians' attitudes, beliefs, and practices regarding clinical practice guidelines: a national survey. Pediatrics 2000;105: 496-501.
28. Halterman JS, Yoos HL, Kaczorowski JM, McConnochie K, Holzhauer RJ, Conn KM, et al. Providers underestimate symptom severity among urban children with asthma. Arch Pediatr Adolesc Med 2002;156:141-6.
29. Kozyrskyj AL, Mustard CA, Simons FE. Socioeconomic status, drug insurance benefits, and new prescriptions for inhaled corticosteroids in schoolchildren with asthma. Arch Pediatr Adolesc Med 2001;155:1219-24.
30. Riekert KA, Butz AM, Eggleston PA, Huss K, Winkelstein M, Rand CS. Caregiver-physician medication concordance and undertreatment of asthma among inner-city children. Pediatrics 2003;111:e214-20.
31. Sawicki GS, Smith L, Bokhour B, Gay C, Hohman KH, Galbraith AA, et al. Periodic use of inhaled steroids in children with mild persistent asthma: what are pediatricians recommending? Clin Pediatr (Phila) 2008;47:446-51.
32. Boudreaux ED, Emond SD, Clark S, Camargo CA Jr. Race/ethnicity and asthma among children presenting to the emergency department: differences in disease severity and management. Pediatrics 2003;111:e615-21.
33. Lieu TA, Finkelstein JA, Lozano P, Capra AM, Chi FW, Jensvold N, et al. Cultural competence policies and other predictors of asthma care quality for Medicaid-insured children. Pediatrics 2004;114:e102-10.
34. Schulman KA, Berlin JA, Harless W, Kerner JF, Sistrunk S, Gersh BJ, et al. The effect of race and sex on physicians' recommendations for cardiac catheterization. N Engl J Med 1999;340:618-26.
35. Okelo SO, Wu AW, Merriman B, Krishnan JA, Diette GB. Are physician estimates of asthma severity less accurate in black than in white patients? J Gen Intern Med 2007;22:976-81.
36. Burgess DJ, Fu SS, van RM. Why do providers contribute to disparities and what can be done about it? J Gen Intern Med 2004;1154-9.
37. van Ryn M, Burke JE. The effect of patient race and socio-economic status on physicians' perceptions of patients. Soc Sci Med 2000;50:813-28.
38. Apter AJ, Reisine ST, Affleck G, Barrows E, ZuWallack RL. Adherence with twice-daily dosing of inhaled steroids. Socioeconomic and health-belief differences. Am J Respir Crit Care Med 1998;157:1810-7.
39. Wells K, Pladevall M, Peterson EL, Campbell J, Wang M, Lanfear DE, et al. Race-ethnic differences in factors associated with inhaled steroid adherence among adults with asthma. Am J Respir Crit Care Med 2008;178:1194-201.
40. Richardson LD, Babcock Irvin C, Tamayo-Sarver JH. Racial and ethnic disparities in the clinical practice of emergency medicine. Acad Emerg Med 2003; 10:1184-8.
41. Flores G, Abreu M, Schwartz I, Hill M. The importance of language and culture in pediatric care: case studies from the Latino community. J Pediatr 2000;137: 842-8.
42. Diette GB, Rand C. The contributing role of health-care communication to health disparities for minority patients with asthma. Chest 2007;132:802S-9S.
43. Barnes KC. Genetic epidemiology of health disparities in allergy and clinical immunology. J Allergy Clin Immunol 2006;117:243-56.
44. Burchard EG, Avila PC, Nazario S, Casal J, Torres A, Rodriguez-Santana JR, et al. Lower bronchodilator responsiveness in Puerto Rican than in Mexican subjects with asthma. Am J Respir Crit Care Med 2004;169:386-92.
45. National Asthma Education and Prevention Program. Expert panel report 3: guidelines for the diagnosis and management of asthma. Available at: http://www.nhlbi.nih.gov/guidelines/asthma. Accessed May 6, 2009.
46. Bearison DJ, Minian N, Granowetter L. Medical management of asthma and folk medicine in a Hispanic community. J Pediatr Psychol 2002;27:385-92.
47. Koinis-Mitchell D, McQuaid EL, Seifer R, Kopel SJ, Esteban C, Canino G, et al. Multiple urban and asthma-related risks and their association with asthma morbidity in children. J Pediatr Psychol 2007;32:582-95.
48. George M, Birck K, Hufford DJ, Jemmott LS, Weaver TE. Beliefs about asthma and complementary and alternative medicine in low-income inner-city African-American adults. J Gen Intern Med 2006;21:1317-24.
49. Mansour ME, Lanphear BP, DeWitt TG. Barriers to asthma care in urban children: parent perspectives. Pediatrics 2000;106:512-9.
50. Pachter LM, Cloutier MM, Bernstein BA. Ethnomedical (folk) remedies for childhood asthma in a mainland Puerto Rican community. Arch Pediatr Adolesc Med 1995;149:982-8.
51. Conn KM, Halterman JS, Lynch K, Cabana MD. The impact of parents' medication beliefs on asthma management. Pediatrics 2007;120:e521-6.
52. McQuaid EL, Koinis Mitchell D, Walders N, Nassau JH, Kopel SJ, Klein RB, et al. Pediatric asthma morbidity: the importance of symptom perception and family response to symptoms. J Pediatr Psychol 2007;32:167-77.
53. Bender B, Boulet LP, Chaustre I, Rand C. Asthma. In: Adherence to long-term therapies: evidence for action. Geneva, Switzerland: World Health Organization; 2003.
54. Williams LK, Joseph CL, Peterson EL, Moon C, Xi H, Krajenta R, et al. Race-ethnicity, crime, and other factors associated with adherence to inhaled corticosteroids. J Allergy Clin Immunol 2007;119:168-75.
55. Bender BG, Rankin A, Tran ZV, Wamboldt FS. Brief-interval telephone surveys of medication adherence and asthma symptoms in the Childhood Asthma Management Program Continuation Study. Ann Allergy Asthma Immunol 2008;101: 382-6.
56. McQuaid EL, Kopel SJ, Klein RB, Fritz GK. Medication adherence in pediatric asthma: reasoning, responsibility, and behavior. J Pediatr Psychol 2003;28:323-33.
57. Le TT, Bilderback A, Bender B, Wamboldt FS, Turner CF, Rand CS, et al. Do asthma medication beliefs mediate the relationship between minority status and adherence to therapy? J Asthma 2008;45:33-7.
58. Apter AJ, Boston RC, George M, Norfleet AL, Tenhave T, Coyne JC, et al. Modifiable barriers to adherence to inhaled steroids among adults with asthma: it's not just black and white. J Allergy Clin Immunol 2003;111:1219-26.
59. Gazmararian JA, Baker DW, Williams MV, Parker RM, Scott TL, Green DC, et al. Health literacy among Medicare enrollees in a managed care organization. JAMA 1999;281:545-51.
60. Wolf MS, Gazmararian JA, Baker DW. Health literacy and functional health status among older adults. Arch Intern Med 2005;165:1946-52.
61. Williams MV, Baker DW, Honig EG, Lee TM, Nowlan A. Inadequate literacy is a barrier to asthma knowledge and self-care. Chest 1998;114:1008-15.
62. Paasche-Orlow MK, Riekert KA, Bilderback A, Chanmugam A, Hill P, Rand CS, et al. Tailored education may reduce health literacy disparities in asthma self-management. Am J Respir Crit Care Med 2005;172:980-6.
63. Williams DR, Jackson PB. Social sources of racial disparities in health. Health Aff (Millwood) 2005;24:325-34.
64. Pearlman DN, Zierler S, Meersman S, Kim HK, Viner-Brown SI, Caron C. Race disparities in childhood asthma: does where you live matter? J Natl Med Assoc 2006;98:239-47.
65. Link BG, Phelan J. Social conditions as fundamental causes of disease. J Health Soc Behav 1995;Spec No):80-94.
66. Clark NM, Brown R, Joseph CL, Anderson EW, Liu M, Valerio M, et al. Issues in identifying asthma and estimating prevalence in an urban school population. J Clin Epidemiol 2002;55:870-81.
67. Claudio L, Stingone JA, Godbold J. Prevalence of childhood asthma in urban communities: the impact of ethnicity and income. Ann Epidemiol 2006;16:332-40.
68. Saha C, Riner ME, Liu G. Individual and neighborhood-level factors in predicting asthma. Arch Pediatr Adolesc Med 2005;159:759-63.
69. Juhn YJ, Sauver JS, Katusic S, Vargas D, Weaver A, Yunginger J. The influence of neighborhood environment on the incidence of childhood asthma: a multilevel approach. Soc Sci Med 2005;60:2453-64.
70. Ren XS, Amick BC, Williams DR. Racial/ethnic disparities in health: the interplay between discrimination and socioeconomic status. Ethn Dis 1999;9:151-65.
71. Ellen IG, Mijanovich T, Dillman KN. Neighborhood effects on health: exploring the links and assessing the evidence. J Urban Affairs 2001;23:391-408.
72. Leventhal T, Brooks-Gunn J. The neighborhoods they live in: the effects of neighborhood residence on child and adolescent outcomes. Psychol Bull 2000;126:309-37.
73. Rosenstreich DL, Eggleston P, Kattan M, Baker D, Slavin RG, Gergen P, et al. The role of cockroach allergy and exposure to cockroach allergen in causing morbidity among inner-city children with asthma. N Engl J Med 1997;336:1356-63.
74. Claudio L, Tulton L, Doucette J, Landrigan PJ. Socioeconomic factors and asthma hospitalization rates in New York City. J Asthma 1999;36:343-50.
75. Choudhury AH, Gordian ME, Morris SS. Associations between respiratory illness and PM10 air pollution. Arch Environ Health 1997;52:113-7.

76. Berman BA, Wong GC, Bastani R, Hoang T, Jones C, Goldstein DR, et al. Household smoking behavior and ETS exposure among children with asthma in low-income, minority households. Addict Behav 2003;28:111-28.
77. U.S. Department of Health and Human Services. The health consequences of involuntary exposure to tobacco smoke: a report of the Surgeon General. Atlanta (GA): US Department of Health and Human Services, Centers for Disease Control and Prevention, Coordinating Center for Health Promotion, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2006.
78. Hudson CG. Socioeconomic status and mental illness: tests of the social causation and selection hypotheses. Am J Orthopsychiatry 2005;75:3-18.
79. Kozyrskyj AL, Mai XM, McGrath P, Hayglass KT, Becker AB, Macneil B. Continued exposure to maternal distress in early life is associated with an increased risk of childhood asthma. Am J Respir Crit Care Med 2008;177:142-7.
80. Mrazek DA, Klinnert MD, Mrazek P, Macey T. Early asthma onset: consideration of parenting issues. J Am Acad Child Adolesc Psychiatry 1991;30:277-82.
81. Wright RJ, Mitchell H, Visness CM, Cohen S, Stout J, Evans R, et al. Community violence and asthma morbidity: the Inner-City Asthma Study. Am J Public Health 2004;94:625-32.
82. Wright RJ, Cohen RT, Cohen S. The impact of stress on the development and expression of atopy. Curr Opin Allergy Clin Immunol 2005;5:23-9.
83. Wright RJ. Stress and atopic disorders. J Allergy Clin Immunol 2005;116:1301-6.
84. Sandberg S, Paton JY, Ahola S, McCann DC, McGuinness D, Hillary CR, et al. The role of acute and chronic stress in asthma attacks in children. Lancet 2000;356:982-7.
85. Chen E, Hanson MD, Paterson LQ, Griffin MJ, Walker HA, Miller GE. Socioeconomic status and inflammatory processes in childhood asthma: the role of psychological stress. J Allergy Clin Immunol 2006;117:1014-20.
86. Hasin DS, Goodwin RD, Stinson FS, Grant BF. Epidemiology of major depressive disorder: results from the National Epidemiologic Survey on Alcoholism and Related Conditions. Arch Gen Psychiatry 2005;62:1097-106.
87. McCauley E, Katon W, Russo J, Richardson L, Lozano P. Impact of anxiety and depression on functional impairment in adolescents with asthma. Gen Hosp Psychiatry 2007;29:214-22.
88. Opolski M, Wilson I. Asthma and depression: a pragmatic review of the literature and recommendations for future research. Clin Pract Epidemol Ment Health 2005;1:18.
89. ten Brinke A, Ouwerkerk ME, Zwinderman AH, Spinhoven P, Bel EH. Psychopathology in patients with severe asthma is associated with increased health care utilization. Am J Respir Crit Care Med 2001;163:1093-6.
90. Alegría M, Pescosolido B, Canino G. A socio-cultural framework for mental health and substance abuse service disparities. In: Sadock BJ, Sadock VA, Ruiz P, editors. Comprehensive textbook of psychiatry. Baltimore: Wolters Kluwer Health, Lippincott Williams & Wilkins. In press.
91. McGuire TG, Alegria M, Cook BL, Wells KB, Zaslavsky AM. Implementing the Institute of Medicine definition of disparities: an application to mental health care. Health Serv Res 2006;41:1979-2005.
92. van Ryn M, Fu SS. Paved with good intentions: do public health and human service providers contribute to racial/ethnic disparities in health? Am J Public Health 2003; 93:248-55.
93. Subramanian SV, Chen JT, Rehkopf DH, Waterman PD, Krieger N. Racial disparities in context: a multilevel analysis of neighborhood variations in poverty and excess mortality among black populations in Massachusetts. Am J Public Health 2005;95: 260-5.
94. Apter AJ. The influence of health disparities on individual patient outcomes: what is the link between genes and environment? J Allergy Clin Immunol 2006;117:345-50.
95. Joseph CL, Williams LK, Ownby DR, Saltzgaber J, Johnson CC. Applying epidemiologic concepts of primary, secondary, and tertiary prevention to the elimination of racial disparities in asthma. J Allergy Clin Immunol 2006;117:233-42.
96. Passel J, Cohen D. Immigrant to play lead role in future US growth. Washington (DC): Pew Research Center; 2008.